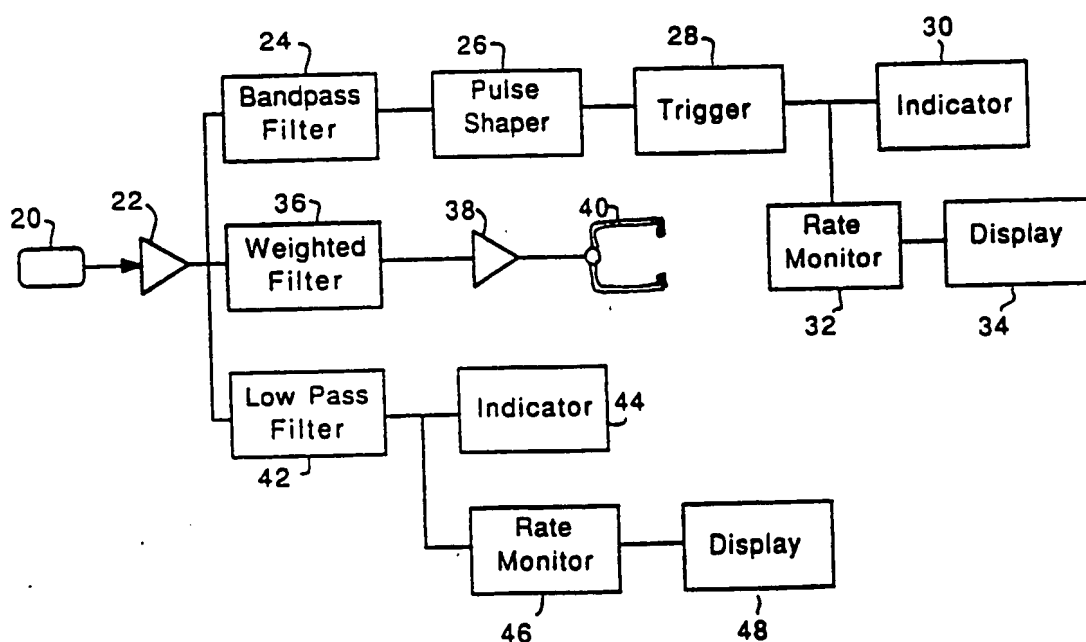




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(54) Title: VITAL LIFE SIGN DETECTOR



(57) Abstract

A vital life sign detector which can be used to determine heart and respiration activity in an individual wearing bulky clothing, such as chemical warfare protective clothing. A detector (20), such as an accelerometer or geophone, detects chest wall vibrations of an individual and produces an output signal (22) in response thereto. The output signal is processed to determine the existence of cardiac and respiratory activity. The output signal can be further processed to calculate the heart rate and respiratory rate of the individual. The system produces a visual (34) or audio signal (40) which allows medical personnel to determine quickly

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VITAL LIFE SIGN DETECTOR

1

**2 Field of
3 the invention**

4 The present invention relates generally to systems for detecting vital life signs in
5 individuals. More specifically, the present invention provides a method and apparatus for
6 detecting vital life signs, such as heart rate and respiration, in an individual wearing heavy
7 garments or other covering. An example of such an individual would be a soldier
8 wearing arctic clothing or chemical warfare protective gear.

**9 Background of
10 the invention**

11 The first step in a medical emergency is to determine whether the heart is beating
12 and breathing is present. The heartbeat is classically found by palpating the pulse in the
13 wrist, neck, or ankle, or by listening to the chest with a stethoscope or ear. Breathing is
14 typically detected by observing motion of the chest and abdomen or sensing airflow
15 through the nose and mouth.

16 Situations occur, particularly in wartime, in which it is not possible for a human to
17 sensorially detect the pulse or breathing. This is particularly true during arctic or
18 chemical warfare where the casualty and the medical personnel may be completely
19 encased in heavy clothing and may be wearing heavy gloves or masks. Blood loss,
20 shock, and trauma may also reduce the intensity of the pulse and respiration which make
21 sensory detection of vital life signs difficult and time consuming.

22 In situations where large numbers of casualties are present, it is important that care

2 determining the presence of a pulse and breathing is, therefore, a central issue in casualty
3 management.

4 The prior art has heretofore failed to provide a system for quickly detecting vital life
5 signs in individuals, such as wartime casualties, who are wearing bulky protective
6 clothing. The vital life sign detector of the present invention, described in greater detail
7 below, fulfills this need.

2 the invention

3 The vital life sign detector of the present invention overcomes the difficulties of the
4 prior art by providing a system which can be used to determine heart and respiration
5 activity in an individual wearing bulky protective coating. In the preferred embodiment
6 of the invention, a detector, such as an accelerometer or geophone, detects chest wall
7 vibrations of an individual and produces an output signal in response thereto. The output
8 signal is processed to determine the existence of cardiac and respiratory activity. The
9 output signal can be further processed to calculate the heart rate and respiration rate of
10 the individual. Numerous types of transducers can be used to detect the chest wall
11 vibrations, including piezoelectric, electromagnetic and resistive transducers.

12 The system of the present invention is contained in a housing which fits comfortably
13 in the gloved hand of medical personnel and requires little dexterity to activate. The
14 housing also has dimensions which allow it to be stable when at rest on the individual,
15 even when the chest surface is at large angles relative to horizontal. The total mass of
16 the device is sufficient to hold the detector effectively stationary relative to the body of
17 the patient. The bottom surface of the housing is covered with a nonslip coating to
18 prevent sliding off the chest.

2 of the Drawings

3 FIG. 1 is an illustration of the vital life sign detector of the present invention placed
4 on an individual.

5 FIG. 2 is a schematic illustration of the signal processing electronics employed in
6 the vital life sign detector of the present invention.

7 FIG. 3a is a graphical representation of an ECG signal produced by an individual.

8 FIG. 3b is a graphical representation of the output signal of the motion detector
9 employed in the present invention.

2 the Preferred Embodiment

3 FIG. 1 is an illustration of the vital life sign detector of the present invention placed
4 on the chest of an immobilized individual 12. The detector 10 is provided with an
5 appropriate display to allow the medical aid personnel 14 to quickly determine whether
6 the individual 12 is alive. The beating of the heart and breathing produce movements and
7 accelerations of the individual's body due to changes in organ volume and momentum
8 transfers. These accelerations and movements can be used to provide an indication of
9 cardiac output and respiratory volume changes. The movements range from very low
10 frequencies (respiration: 0.1 to 0.5 Hz; heart rate: 0.5 to 4 Hz) to relatively high
11 frequencies (breath sounds: 100 to 2000 Hz; heart sounds and bruits: 40 to 1000 Hz).
12 These movements and vibrations normally can be detected with the finger or with the aid
13 of a stethoscope applied to the bare skin. However, when clothing or other coupling
14 materials are introduced between the skin and human sensor, the vibrations and sounds
15 are filtered with the high frequency components that are normally sensorially detectable
16 being filtered out. It has been observed by the inventor, however, that the low frequency
17 components are attenuated to a far lesser extent and can be sensed with low frequency
18 acceleration measurement devices. The system of the present invention utilizes these low
19 frequency signals to provide an indication of the existence of vital life signs.

20 In summary, the vital life sign detector is a small device which, when placed upon
21 a subject, will detect the mechanical vibrations associated with respiratory and heart
22 movement. Typically, the device is placed on the chest of the supine casualty. The
23 medical aid provider removes his hand and observes the face of the device. A display

2 A second display indicates respiratory motion and displays the respiration rate.

3 As shown schematically in FIG. 2, the chest wall vibrations produced by cardiac and
4 respiratory motions are detected with one or more motion detectors 20, such as an
5 accelerometer or geophone. The motion detectors 20 can use any of a number of
6 transducers, including, but not limited to, piezoelectric, resistive, or electromagnetic. An
7 example of the typical output signal from the motion detector 20 is illustrated in FIG. 3b.
8 The ECG signal is shown in FIG. 3a for reference. It should be noted that there are two
9 pulses associated with each heart beat. These pulses correspond to the onsets of systole
10 and diastole and are synchronous with the first and second heart sounds.

11 The signal from the motion detector 20 is first amplified in an appropriate amplifier
12 22 and then conditioned in several ways. First, for heart rate, the signal is processed by
13 an analog or digital bandpass filter 24 having a pass band from about 0.5 to about 300
14 Hz. The transient oscillations are converted and smoothed into a pulse by a pulse shaper
15 circuit 26. The shaped pulse signal is then fed to a level sensitive, timed, one shot trigger
16 28 which is held on for approximately 300 msec before resetting. The lock-on time is
17 consistent with the ejection time of the heart. This time lock-on is to prevent double
18 triggering by the second pulse. The timed pulse is then used to turn on the front panel
19 pulse indicator 30 to provide an indication of the existence of cardiac activity. The timed
20 pulse is also fed to a rate computation means 32, which can utilize analog, digital or
21 software rate computing techniques, known in the art, to calculate heart rate. The
22 calculated heart rate is displayed on a front panel display 34.

2 to provide a pseudo heart sound output for the user to hear. To provide this signal, the
3 transducer signal is passed through a weighted band pass filter 36 which has a transfer
4 function equivalent to that of a stethoscope. This filtered signal is then fed to a suitable
5 power amplifier 38 which is connected to an earphone 40. In the preferred embodiment
6 of the invention, the earphone is mounted in a stethoscope yoke to facilitate use.

7 The output signal of the motion detector 20 is also provided to a third channel which
8 is used to determine the existence of respiration in the individual by one of several
9 methods. In one method, the detector signal is processed in an extremely low bandpass
10 filter 42. The high frequency cutoff of the filter 42 is approximately five Hz. The overall
11 detector and filter low frequency cutoff should be 0.05 Hz or less. It is preferable that
12 the low frequency cutoff be defined by the detector rather than the subsequent
13 electronics. High pass filtering should not be used to avoid long settling times resulting
14 from any large artifacts introduced into the signal.

15 Another suitable method for detecting respiratory movements from the detector
16 signal is to measure the beat-to-beat changes in the intensity of the pulses. The intensity
17 of the pulses are due, in part, to the compliance of the chest within which the heart is
18 beating. The compliance of the chest is dependent upon the volume of air contained
19 within the lungs and the muscle tension of the chest muscle, both of which will change
20 during the course of respiration. The cyclical compliance variations during breathing
21 produce the cyclical variations in the detected pulse amplitudes.

22 The low frequency components produced by filtering methods or the variations in

2 Either signal is also fed to a rate computation means which can utilize analog, digital, or
3 software rate computing techniques, known in the art, to calculate respiration rate.

4 Careful attention to the housing design is required for the detector to operate
5 properly to detect heart beat and respiration through garments. The device should fit
6 comfortably in the gloved hand of medical personnel and should require little dexterity
7 to activate. The housing should have dimensions which allow it to be stable when at rest
8 on the individual, even when the chest surface is at large angles relative to horizontal.
9 The total mass of the device must be sufficient to hold the detector effectively stationary
10 relative to the body of the patient. A rectangular box of 4" x 3" x 1" having a weight of
11 one pound has been found to be a satisfactory upper limit. The bottom surface of the
12 housing should also be covered with a nonslip coating to prevent sliding off the chest.
13 The displays should be large and designed to be easily read especially from low angles
14 relative to the display. Finally, the device package should be sealed against contaminants
15 since, as an emergency device, it will be used in hostile environments.

16 Although the vital life sign detector of the present invention has been described in
17 connection with the preferred embodiment, it is not intended to be limited to the specific
18 form set forth herein, but on the contrary, it is intended to cover such modifications,
19 alternatives, and equivalents as can be reasonably included within the spirit and scope of
20 the invention as defined by the appended claims.

- 2 1. A system for detecting vital life signs in an individual, comprising:
3 means for detecting vibrations in the chest wall of an individual and for
4 producing an output signal in response thereto, even when said
5 individual is wearing bulky clothing;
6 means for correlating said output signal with vital life signs of said
7 individual.

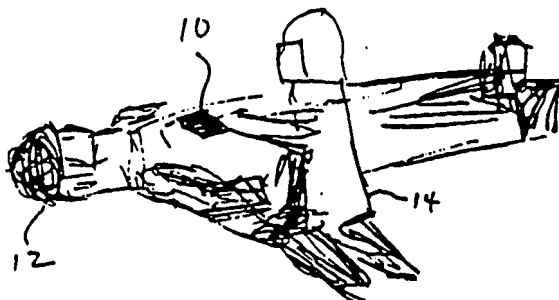
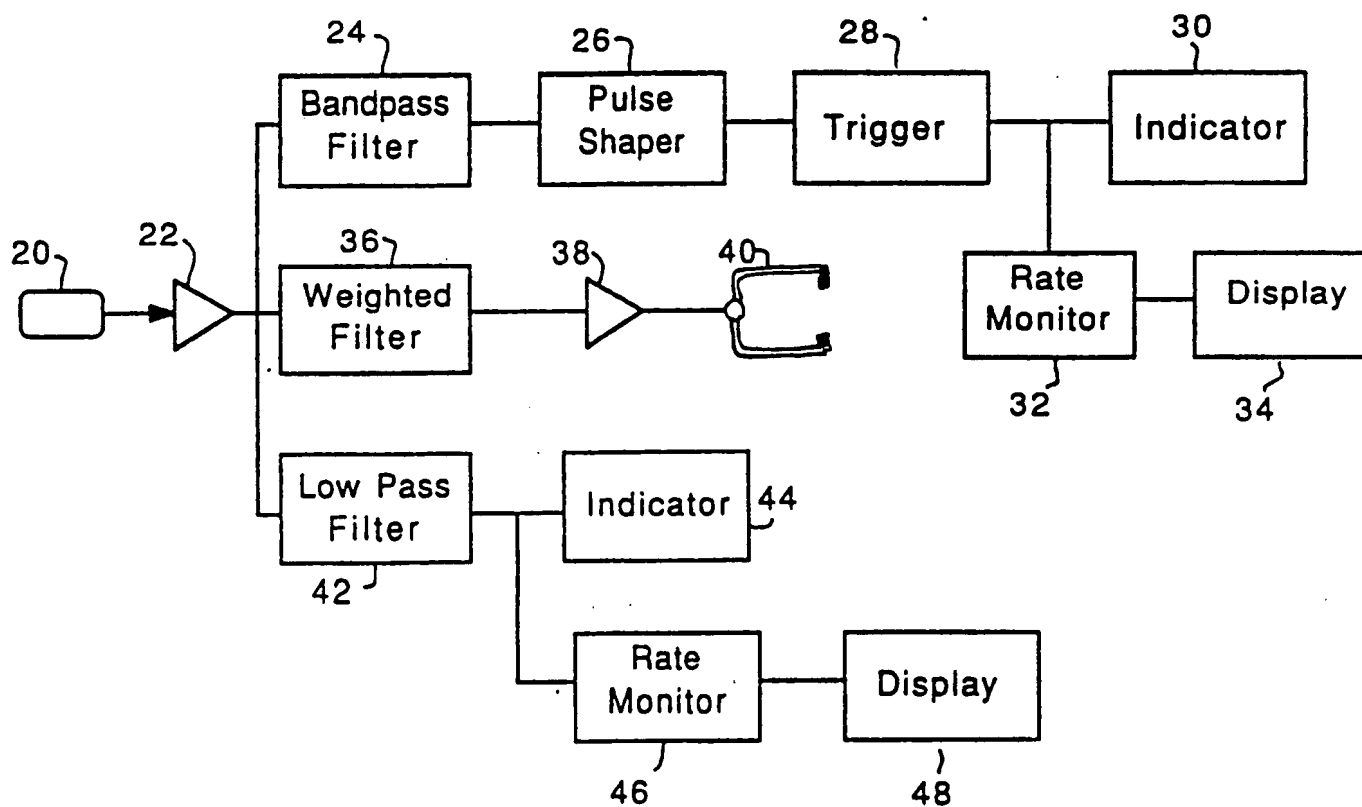
- 2 vibrations comprising a piezoelectric transducer.
- 3 3. The system according to claim 1, said means for detecting said chest wall
4 vibrations comprising a electromagnetic transducer.
- 5 4. The system according to claim 1, said means for detecting said chest wall
6 vibrations comprising a resistive transducer.
- 7 5. The system according to claim 1, further comprising means for processing
8 said output signal to provide an indication of heart sounds produced by said
9 individual.
- 10 6. The system according to claim 5, further comprising means for using said
11 heart sounds to calculate the heart rate of said individual.
- 12 7. The system according to claim 6, further comprising a weighted bandpass
13 filter for processing said output signal, said weighted bandpass filter having
14 a transfer function equivalent to that of a stethoscope to provide an electrical
15 signal representation of audible heart sounds, and an audio signal transducer
16 to convert said electrical representation into an audible heart sound.

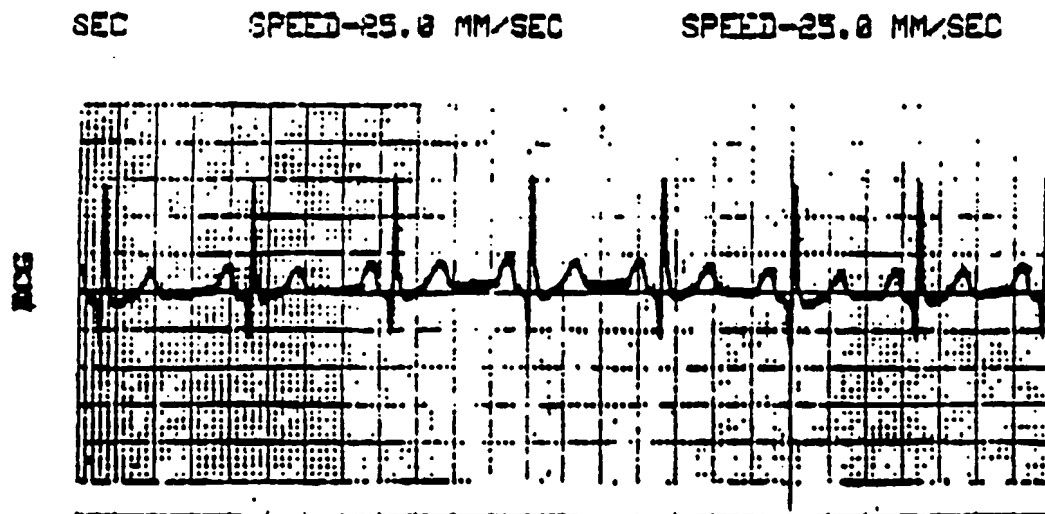
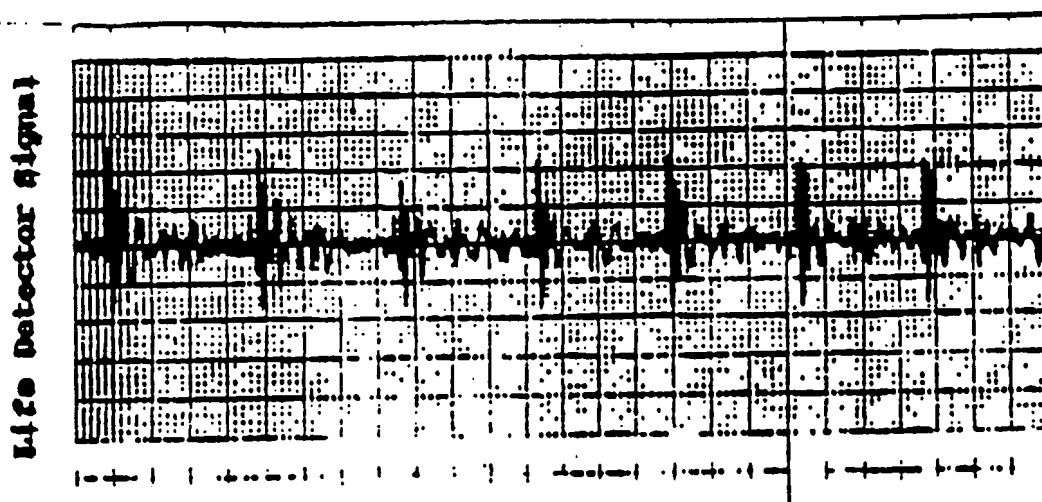
2 said output signal to determine the existence of respiration in said individual.

3 9. The system according to claim 8, further comprising means for calculating
4 the respiration rate of said individual.

5 10. The system according to claim 1, said system being contained in a housing
6 having sufficient mass to maintain said detector in an effectively stationary
7 position relative to the body of said individual.

2 A vital life sign detector which can be used to determine heart and respiration activity
3 in an individual wearing bulky clothing, such as chemical warfare protective clothing.
4 A detector, such as an accelerometer or geophone, detects chest wall vibrations of an
5 individual and produces an output signal in response thereto. The output signal is
6 processed to determine the existence of cardiac and respiratory activity. The output signal
7 can be further processed to calculate the heart rate and respiration rate of the individual.
8 The system produces a visual or audio signal which allows medical personnel to
9 determine quickly whether the individual is alive.

FIG. 1FIG. 2

FIG. 3aFIG. 3b

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US91/08905

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) *

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5): A61B 5/0255

US CL 128/715

II. FIELDS SEARCHED

Minimum Documentation Searched *

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US

128/715

Documentation Searched other than Minimum Documentation
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III. DOCUMENTS CONSIDERED TO BE RELEVANT *

Category *	Citation of Document, ** with indication, where appropriate, of the relevant passages †	Relevant to Claim No. ‡
X, p Y	US, A, 5,002,060 (NEDIVI) 26 MARCH 1991 See entire document.	<u>1,2,8-10</u> <u>3,4-7</u>
Y	US, A, 4,840,183 (TAKAHASHI) 20 JUNE 1989 See entire document.	3
Y,P	US, A, 5,010,890 (PFOHL) 30 APRIL 1991 See entire document.	5-7
A,P	US, A, 4,972,841 (IGUCHI) 27 NOVEMBER 1990 See abstract.	1
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IV. CERTIFICATION

Date of the Actual Completion of the International Search

Date of Mailing of this International Search Report

30 JANUARY 1992

02 MAR 1992

International Searching Authority

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